AN EVALUATION OF THE TRW METHOD OF COMBINING POINT ESTIMATES OF RELIABILITY

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THESIS

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ABSTRACT

A computer program was written that carries out reliability assessments according to a method proposed by the TRW Corporation. This method combines point estimates for reliability from different sources into an overall point estimate. The program was used to calculate the overall point estimate for cases covering a range of sample sizes, and underlying probabilities of success in order to make a judgement on the usefulness of the method.

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I. INTRODUCTION

In deriving a point estimate for the reliability of a system or component, there is no universally accepted method for combining data from more than one test environment. For example, if a system on a test stand performs its intended function four times out of five trials, and in another environment, say actual use, it performs its function in two out of three trials, the point estimates for system reliability in the two environments would be 4/5 and 2/3 respectively. It is not clear how these two estimates from different environments should be combined into a single point estimate of realiabiltiy.

The Quality Evaluation Laboratory, U.S. Naval Ammunition Depot, Oahu, Hawaii, published a procedure to accomplish this integration of trial data by comparing all data sets to a base data set and generating weighting factors for each data set. TRW Corporation wrote a computer routine to carry out the required computations for this method and proposed the method be adopted use in certain development programs.

The TRW computer program was not available for this study and so two programs were written as part of this project. Each program has certain limitations in use, but together they cover a complete range of method parameters.

II. THE METHOD

Consider a series of n trials of a system of which m are judged successes. Then the probability that R is the underlying reliability of the system is given by the binomial distribution.

$$P(R) = {}_nC_m \; R^m (1-R)^{n-m}, \quad (0 \leq R \leq 1).$$

This relationship generates a probability density function such as is shown in figure 1. This is the likelihood function of R given m successes in n trials.

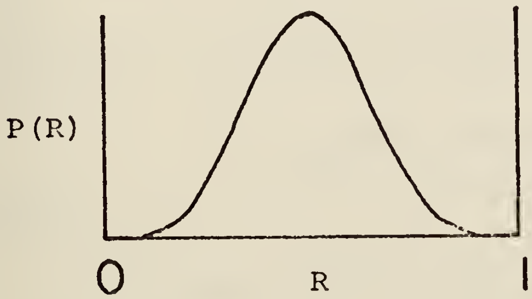

FIGURE 1. Likelihood function of R given m successes in n trials.

To evaluate percentiles of the binomial distribution, the incomplete beta function[1] can be used through the following identity:

$$I_R(a,n-a+1) = \sum_{x=a}^{n} {}_nC_x R^x (1-R)^{n-x}$$, n and k positive integers.

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[1]The incomplete beta function is defined

$$I_x(a,b) = \frac{1}{B(a,b)} \int_0^x t^{a-1}(1-t)^{b-1} \, dt, \quad (0 \leq t \leq 1)$$

where

$$B(a,b) = \frac{\Gamma(a)\Gamma(b)}{\Gamma(a+b)}$$

The incomplete beta family is extensively tabled and efficient computer routines have been written to compute $I_x(a,b)$.

If the probability density function for a second set of test data is superimposed on the first density function, a representation such as figure 2 results.

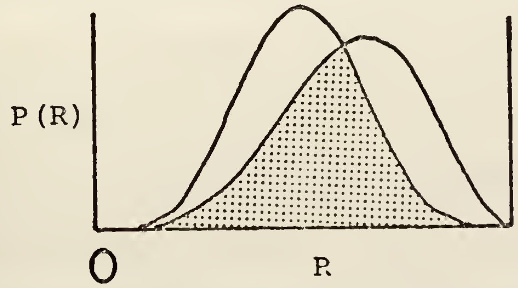

FIGURE 2. Two likelihood functions showing overlap.

The TRW method uses the amount of overlap as a weighting factor that measures the extent of agreement between the two sets of data. Calculating the weighting factor can be done by first solving for points of intersection of the two curves. These are all points x which are solutions to the equation

$$ {}_nC_m x^m (1-x)^{n-m} = {}_pC_s \, x^s (1-x)^{p-s} $$

where

n = number of trials in data set 1

m = number of successes in data set 1

p = number of trials in data set 2

s = number of successes in data set 2

This expression simplifies to

$$ x^{m-s} (1-x)^{n-m-p+s} = \frac{p! \; (n-m)! \; m!}{(p-s)! \; s! \; n!} $$

This is a polynomial of degree n-p.

With the points of intersection determined, the TRW method determines the weighting factor by summing the area under that curve which is the lower between each intersection. See figure 2.

The two computer programs included in this report perform these calculations. Limitations on the programs are discussed in the descriptions that introduce each program.

To calculate a point estimate of reliability using the TRW method, each set of data, i = 1,2,...,n, is compared with a set of base data and a weighting factor, k_i, is determined as discussed above. These weighting factors are then applied to the point estimates to determine the overall estimate as follows:

$$R = \frac{1.0(P_b') + k_1(P_1') + k_2(P_2') + \ldots + k_n(P_n')}{1.0 + k_1 + k_2 \ldots + k_n}$$

where

R = overall point estimate of reliability

P_i' = point estimate from i^{th} data set

P_b' = point estimate from base data set

k_i = weighting factor from i^{th} data set

i = 1,2, ...,n

III. ANALYSIS OF TRW METHOD

The magnitude of the weighting factor or overlap used in this method is determined by the relationship between the two incomplete beta functions used to represent the data sets. Specifically, the overlap is a function of (1) the location of the mean of each curve relative to the mean of the other end and (2) the spread or variance of each curve.[1] A particular realization of the beta function tends to become spike shaped as the number of trials is increased. This effect is shown in table 1 which lists by way of example seven data sets, all having a mean of .8000.

Number of trials	Beta curve	Variance
9	B(x;5,4)	.0246
18	B(x;10,8)	.0129
25	B(x;20,5)	.0062
40	B(x;32,8)	.0039
50	B(x;40,10)	.0031
60	B(x;48,12)	.0026
100	B(x;80,20)	.0016

Table 1. As the number of trials is increased, the variance of the beta distribution representation decreases. The means of all data sets is .8000.

It was hypothesized that the weighting factor would be relatively small (and consequently the TRW method would have only

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[1]The mean and variance of the beta distribution representing a data set with s successes and f failures are

$$\text{mean} = \frac{s}{(s+f)} \qquad \text{variance} = \frac{s \times f}{(s+f)^2 \times (s+f+1)} .$$

a minor effect on reliability calculations) when (1) the ratios of successes to total trials from each data set were widely displaced from each other, or (2) when the number of trials in either data set was not small and the ratio of successes to number of trials were more than a little displaced from each other.

To investigate this idea, pairs of test data sets and base data sets were compared and a weighting factor and point estimate of reliability was determined using the TRW method and the computer routines written for this project. A range of probabilities of success on a single trial and total number of trials was considered for both base and test data sets. Thirty six pairs were considered.

Table 2 is a tabulation of the data from the investigation. The number of trials in the base set, n_b, and in the trial data set, n_t, are shown for each case as are the underlying probabilities of success on a single trial, P_b for the base data and P_t for the trial data. Each of the ten replications using these parameters resulted in a number of successes, s_b and s_t, and point estimates of reliability, P_b' and P_t'. These last were calculated as

$$P_b' = \frac{s_b}{n_b} \quad \text{and} \quad P_t' = \frac{s_t}{n_t} .$$

The number of successes and the number of failures in each replication were inputs into the computer program which generated the TRW weighting factor, K. The TRW point estimate

	Base Data Sets				Test Data Set						
Case Number	No. of Trials n_b	Single Trial Prob. of Success P_b	Average No. of Successes $\overline{s}_b$	Average Point Estimate of reliability $\overline{P}'_b$	No. of Trials n_t	Single Trial Prob of Success P_t	Average No. of Successes $\overline{s}_t$	Average Point Estimate of Reliability $\overline{P}'_t$	Average TRW Method Weighting Factor $\overline{K}$	Average TRW Method Reliability Estimate (with Standard Deviation) $\overline{R}$	Average Adjustment to Base Data Point Estimate $\lvert\overline{R-P'_b}\rvert$
1	10	.99	9.0	.90	20	.80	16.4	.82	.5971	.8771 (.0149)	.0229
2	10	.90	8.3	.83	20	.99	18.9	.945	.4970	.8597 (.0579)	.0297
3	10	.80	7.6	.76	20	.99	18.9	.945	.3977	.7896 (.1378)	.0296
4	20	.99	18.9	.945	10	.90	8.3	.83	.4970	.9153 (.0100)	.0297
5	20	.99	18.9	.945	10	.80	7.6	.76	.3977	.9154 (.0200)	.0296
6	20	.80	16.4	.82	10	.99	9.0	.90	.5971	.8429 (.0625)	.0229
7	25	.99	24.0	.96	50	.90	46.1	.922	.5595	.9493 (.0077)	.0107
8	25	.99	24.0	.96	50	.80	41.1	.822	.1868	.9449 (.0044)	.0151
9	25	.99	23.8	.952	50	.80	39.0	.780	.1041	.9380 (.0303)	.0140
10	25	.95	23.1	.924	50	.90	45.3	.906	.7782	.9181 (.0267)	.0059
11	25	.95	23.7	.948	50	.80	39.0	.78	.1351	.9334 (.0256)	.0146
12	25	.90	22.4	.896	50	.99	49.0	.98	.3048	.9109 (.0385)	.0149
13	25	.80	20.3	.812	50	.99	49.0	.98	.0953	.8220 (.0608)	.0100

Table 2

	n_b	P_b	$\bar{s}_b$	$\bar{P}'_b$	n_t	P_t	$\bar{s}_t$	$\bar{P}'_t$	$\bar{K}$	$\bar{R}$		$\lvert\overline{R-P'_b}\rvert$
14	25	.80	19.8	.792	50	.99	48.8	.976	.0817	.8019	(.0546)	.0099
15	25	.80	19.4	.776	50	.95	47.9	.958	.1171	.7904	(.0682)	.0144
16	50	.99	49.0	.98	25	.90	22.4	.8960	.3048	.9651	(.0029)	.0149
17	50	.99	49.0	.98	25	.80	20.3	.8120	.0953	.9700	(.0043)	.0100
18	50	.99	48.8	.976	25	.80	19.8	.792	.0817	.9661	(.0183)	.0099
19	50	.95	47.9	.958	25	.80	19.4	.776	.1171	.9436	(.0254)	.0144
20	50	.90	46.1	.922	25	.99	24.0	.96	.5595	.9327	(.0233)	.0107
21	50	.90	45.3	.906	25	.95	23.1	.924	.7282	.9119	(.0265)	.0059
22	50	.80	41.1	.822	25	.99	24.0	.96	.1868	.8371	(.0639)	.0153
23	50	.80	39.0	.78	25	.99	23.8	.952	.1041	.7940	(.0489)	.0140
24	50	.80	39.0	.78	25	.95	23.7	.948	.1351	.7946	(.0522)	.0146
25	50	.99	48.8	.976	100	.90	89.5	.895	.1663	.9694	(.0120)	.0106
26	50	.99	48.8	.976	100	.80	80.0	.80	.0153	.9737	(.0146)	.0023
27	50	.95	47.3	.964	100	.90	89.9	.899	.2634	.9538	(.0175)	.0107
28	50	.95	47.3	.964	100	.80	80.0	.80	.0878	.9379	(.0327)	.0081
29	50	.80	41.9	.838	100	.99	98.7	.987	.0280	.8408	(.0537)	.0028
30	50	.80	39.05	.781	100	.95	96.0	.96	.0424	.7822	(.0803)	.0012
31	100	.99	98.7	.987	50	.80	41.9	.838	.0280	.9842	(.0111)	.0028
32	100	.95	96.0	.96	50	.80	39.05	.781	.0424	.9588	(.0189)	.0012
33	100	.90	89.5	.895	50	.99	48.8	.978	.1663	.9016	(.0247)	.0066
34	100	.90	89.9	.899	50	.95	47.3	.964	.2634	.9092	(.0193)	.0099
35	100	.80	80.0	.80	50	.99	48.8	.976	.0153	.8023	(.0339)	.0023
36	100	.80	80.0	.80	50	.95	47.3	.946	.0878	.8081	(.0372)	.0081

Table 2 (continued)

of reliability, R, was then calculated as

$$R = \frac{1.0 \times P_b' + K \times P_t'}{1.0 + K} .$$

The magnitude of the adjustment to the base data point estimate is the absolute value of the difference $R-P_b'$. The values generated in the ten replications were averaged and these average values, $\bar{s}_b$, $\bar{P}_b'$, $\bar{s}_t$, $\bar{P}_t'$, $\bar{K}$, $\bar{R}$, and $|\overline{R-P_b'}|$, are the entries in table 2.

By way of example, consider case 1. In this case, the base data set consisted of ten trials (n_b), each with a probability of success of .99 (P_b'). The test data set consisted of twenty trials (n_t), each with a probability of success of .80 (P_t). The results of each of the ten replications are shown below in table 3. (Data from all replications is contained in the computer output section of this report.)

Replication	s_b	P_b'	s_t	P_t'	TRW K	R	$\|R-P_b'\|$
1	9	.90	16	.80	.5024	.8666	.0334
2	9	.90	16	.80	.5024	.8666	.0334
3	9	.90	17	.85	.6641	.8800	.0200
4	9	.90	17	.85	.6641	.8800	.0200
5	9	.90	17	.85	.6641	.8800	.0200
6	9	.90	17	.85	.6641	.8800	.0200
7	9	.90	18	.90	.8673	.9000	.0000
8	9	.90	18	.90	.8673	.9000	.0000
9	9	.90	13	.65	.2019	.8580	.0420
10	9	.90	15	.75	.3731	.8592	.0408
Averages	9.0	.90	16.4	.82	.5971	.8771	.0229

Table 3. Example showing the generation of data for Table 2, Case 1; Base Data Set: $n_b = 10$, $P_b = .99$, Test Data Set: $n_t = 20$, $P_t = .80$.

The last row in table 3 shows the average figures that are the table 2 entries for case 1. Table 2 also lists the standard deviation of the distribution of R for each case.

The data of table 2 shows that the TRW method consistently makes a correction to the point estimate of reliability that is in the proper direction. The largest correction to the point estimate in any of the 360 computations was .042. This occurred when the base data was nine successes out of ten trials and the test data was thirteen successes out of twenty trials. As hypothesized, as the number of trials in either data set increased, or as the point estimates from the data sets diverged, the correction to the point estimate decreased. Whenever the point estimates coincided, there was no correction.

IV. CONCLUSIONS

The correction that the TRW method applies to a base data point estimate decreases as the number of trials in either data set increases or as the point estimates from the data sets diverge. The method probably would adjust the point estimate less than would an observer making a subjective judgement based on the data.

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
10	.90	.80	20	.99	.95	.3577	.8395	.0395
10	.90	.80	20	.99	.95	.3577	.8395	.0395
10	.90	.80	20	.99	.95	.3577	.8395	.0395
10	.90	.80	20	.99	.95	.3577	.8395	.0395
10	.90	.80	20	.99	.95	.3577	.8395	.0395
10	.90	.90	20	.99	.95	.7313	.9211	.0211
10	.90	.90	20	.99	.95	.7313	.9211	.0211
10	.90	.90	20	.99	.95	.7313	.9211	.0211
10	.90	.70	20	.99	.95	.1710	.7365	.0365
10	.90	.90	20	.99	.90	.8170	.9000	.0000
20	.99	.95	10	.80	.70	.1710	.9135	.0365
20	.99	.95	10	.80	.70	.1710	.9135	.0365
20	.99	.95	10	.80	.70	.1710	.9135	.0365
20	.99	.95	10	.80	.60	.0784	.9246	.0254
20	.99	.95	10	.80	.80	.3577	.9105	.0395
20	.99	.95	10	.80	.90	.7313	.9289	.0211
20	.99	.95	10	.80	.90	.7313	.9289	.0211
20	.99	.95	10	.80	.90	.7313	.9289	.0211
20	.99	.95	10	.80	.90	.7313	.9289	.0211
20	.99	.90	10	.80	.50	.1024	.8628	.0372
20	.80	.80	10	.99	.90	.5024	.8334	.0334
20	.80	.80	10	.99	.90	.5024	.8334	.0334
20	.80	.85	10	.99	.90	.6641	.8700	.0200
20	.80	.85	10	.99	.90	.6641	.8700	.0200
20	.80	.85	10	.99	.90	.6641	.8700	.0200
20	.80	.85	10	.99	.90	.6641	.8700	.0200
20	.80	.90	10	.99	.90	.8673	.9000	.0000
20	.80	.90	10	.99	.90	.8673	.9000	.0000
20	.80	.65	10	.99	.90	.2019	.6920	.0420
20	.80	.75	10	.99	.90	.3731	.7908	.0408

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
25	.99	.96	50	.80	.80	.1008	.9453	.0147
25	.99	.96	50	.80	.84	.1803	.9417	.0183
25	.99	.96	50	.80	.84	.1803	.9417	.0183
25	.99	.96	50	.80	.76	.0561	.9494	.0106
25	.99	.96	50	.80	.76	.0561	.9494	.0106
25	.99	.96	50	.80	.78	.0511	.9512	.0088
25	.99	.96	50	.80	.78	.0511	.9512	.0088
25	.99	.88	50	.80	.72	.2073	.8525	.0275
25	.99	.96	50	.80	.82	.1331	.9436	.0164
25	.99	.96	50	.80	.70	.0245	.9538	.0062
25	.95	.92	50	.80	.80	.2588	.8953	.0247
25	.95	.96	50	.80	.84	.1803	.9417	.0183
25	.95	.92	50	.80	.76	.1609	.8978	.0222
25	.95	.96	50	.80	.78	.0511	.9512	.0088
25	.95	.96	50	.80	.78	.0511	.9512	.0088
25	.95	.96	50	.80	.72	.0312	.9527	.0073
25	.95	.96	50	.80	.82	.1331	.9436	.0164
25	.95	.96	50	.80	.76	.0561	.9494	.0106
25	.95	.92	50	.80	.84	.4036	.8970	.0230
25	.95	.96	50	.80	.70	.0245	.9538	.0062
25	.90	.92	50	.99	.98	.3793	.9365	.0165
25	.90	.92	50	.99	.98	.3793	.9365	.0165
25	.90	.92	50	.99	.98	.3793	.9365	.0165
25	.90	.92	50	.99	.98	.3793	.9365	.0165
25	.90	.88	50	.99	.98	.1954	.8963	.0163
25	.90	.88	50	.99	.98	.1954	.8963	.0163
25	.90	.88	50	.99	.98	.1954	.8963	.0163
25	.90	.84	50	.99	.98	.1008	.8528	.0128
25	.90	.84	50	.99	.98	.1008	.8528	.0128
25	.90	.96	50	.99	.98	.7428	.9685	.0085

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.76	50	.99	.98	.0269	.7658	.0058
25	.80	.76	50	.99	.98	.0269	.7658	.0058
25	.80	.80	50	.99	.98	.0516	.8088	.0088
25	.80	.80	50	.99	.98	.0516	.8088	.0088
25	.80	.92	50	.99	.98	.3793	.9365	.0165
25	.80	.72	50	.99	.98	.0132	.7234	.0034
25	.80	.84	50	.95	.96	.2090	.8607	.0207
25	.80	.84	50	.95	.96	.2090	.8607	.0207
25	.80	.76	50	.95	.92	.1833	.7848	.0248
25	.80	.72	50	.95	.98	.0132	.7234	.0034
25	.80	.68	50	.95	.94	.0360	.6890	.0090
25	.80	.76	50	.95	.96	.0636	.7720	.0120
25	.80	.72	50	.95	.96	.0348	.7281	.0081
25	.80	.80	50	.95	.94	.1996	.8233	.0233
25	.80	.76	50	.95	.98	.0261	.7656	.0056
25	.80	.88	50	.95	.98	.1969	.8965	.0165
50	.99	.98	100	.80	.82	.0129	.9780	.0020
50	.99	.98	100	.80	.77	.0037	.9792	.0008
50	.99	.98	100	.80	.77	.0037	.9792	.0008
50	.99	.98	100	.80	.75	.0018	.9796	.0004
50	.99	.94	100	.80	.79	.0530	.9325	.0075
50	.99	.98	100	.80	.79	.0057	.9789	.0011
50	.99	.98	100	.80	.79	.0057	.9789	.0011
50	.99	.98	100	.80	.84	.0222	.9770	.0030
50	.99	.98	100	.80	.84	.0222	.9770	.0030
50	.99	.98	100	.80	.84	.0222	.9770	.0030

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
50	.99	.98	25	.80	.80	.0516	.9712	.0088
50	.99	.98	25	.80	.80	.0516	.9712	.0088
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.76	.0262	.9744	.0056
50	.99	.98	25	.80	.76	.0262	.9744	.0056
50	.99	.98	25	.80	.72	.0131	.9766	.0034
50	.99	.98	25	.80	.72	.0131	.9766	.0034
50	.99	.94	25	.80	.84	.3324	.9151	.0249
50	.95	.92	100	.80	.82	.1919	.9039	.0161
50	.95	.98	100	.80	.77	.0033	.9793	.0007
50	.95	.98	100	.80	.77	.0033	.9793	.0007
50	.95	.94	100	.80	.75	.0215	.9360	.0040
50	.95	.94	100	.80	.79	.0401	.9342	.0058
50	.95	.90	100	.80	.79	.1835	.8829	.0171
50	.95	.92	100	.80	.84	.2727	.9029	.0171
50	.95	.96	100	.80	.84	.0705	.9521	.0079
50	.95	.96	100	.80	.79	.0211	.9565	.0035
50	.95	.96	100	.80	.84	.0705	.9521	.0079
50	.90	.92	25	.99	.96	.5067	.9335	.0135
50	.90	.92	25	.99	.96	.5067	.9335	.0135
50	.90	.92	25	.99	.96	.5067	.9335	.0135
50	.90	.92	25	.99	.96	.5067	.9335	.0135
50	.90	.90	25	.99	.96	.3873	.9168	.0168
50	.90	.88	25	.99	.96	.2959	.8983	.0183
50	.90	.88	25	.99	.96	.2959	.8983	.0183
50	.90	.96	25	.99	.96	.8631	.9600	.0
50	.90	.96	25	.99	.96	.8631	.9600	.0
50	.90	.96	25	.99	.96	.8631	.9600	.0

BASE DATA SET TEST DATA SET

NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
50	.90	.92	25	.95	.92	.8825	.9200	.0000
50	.90	.92	25	.95	.92	.8825	.9200	.0000
50	.90	.86	25	.95	.92	.4989	.8800	.0200
50	.90	.92	25	.95	.96	.5000	.9333	.0133
50	.90	.92	25	.95	.96	.5000	.9333	.0133
50	.90	.86	25	.95	.88	.7790	.8688	.0088
50	.90	.90	25	.95	.88	.9763	.8901	.0099
50	.90	.94	25	.95	.92	.9872	.9301	.0099
50	.90	.88	25	.95	.92	.6126	.8952	.0152
50	.90	.94	25	.95	.96	.6631	.9480	.0080
50	.80	.82	25	.99	.96	.1453	.8378	.0178
50	.80	.82	25	.99	.96	.1453	.8378	.0178
50	.80	.82	25	.99	.96	.1453	.8378	.0178
50	.80	.72	25	.99	.96	.0312	.7273	.0073
50	.80	.80	25	.99	.96	.0987	.8144	.0144
50	.80	.84	25	.99	.96	.1803	.8583	.0183
50	.80	.84	25	.99	.96	.1803	.8583	.0183
50	.80	.92	25	.99	.96	.5074	.9335	.0135
50	.80	.90	25	.99	.96	.3890	.9168	.0168
50	.80	.74	25	.99	.96	.0459	.7497	.0097
50	.80	.76	100	.99	.99	.0006	.7601	.0001
50	.80	.84	100	.99	.99	.0105	.8416	.0016
50	.80	.90	100	.99	.99	.0583	.9050	.0050
50	.80	.92	100	.99	.99	.1077	.9268	.0068
50	.80	.86	100	.99	.99	.0168	.8621	.0021
50	.80	.88	100	.99	.99	.0307	.8833	.0033
50	.80	.82	100	.99	.99	.0052	.8209	.0009
50	.80	.82	100	.99	.99	.0052	.8209	.0009
50	.80	.78	100	.99	.99	.0013	.7803	.0003
50	.80	.80	100	.99	.96	.0437	.8067	.0067

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
50	.80	.76	100	.95	.94	.0273	.7648	.0048
50	.80	.72	100	.95	.98	.0006	.7202	.0002
50	.80	.70	100	.95	.94	.0056	.7013	.0013
50	.80	.76	100	.95	.95	.0168	.7631	.0031
50	.80	.99	100	.95	.96	.3201	.9827	.0073
50	.80	.74	100	.95	.97	.0026	.7406	.0006
50	.80	.78	100	.95	.97	.0088	.7817	.0017
50	.80	.84	100	.95	.99	.0090	.8413	.0013
50	.80	.78	100	.95	.96	.0165	.7829	.0029
50	.80	.74	100	.95	.94	.0164	.7432	.0032
100	.90	.88	50	.99	.98	.0632	.8859	.0059
100	.90	.91	50	.99	.98	.1382	.9185	.0085
100	.90	.91	50	.99	.98	.1382	.9185	.0085
100	.90	.93	50	.99	.98	.2338	.9395	.0095
100	.90	.89	50	.99	.98	.0820	.8968	.0068
100	.90	.89	50	.99	.98	.0820	.8968	.0068
100	.90	.87	50	.99	.98	.0491	.8751	.0051
100	.90	.87	50	.99	.98	.0491	.8751	.0051
100	.90	.87	50	.99	.98	.0491	.8751	.0051
100	.90	.93	50	.99	.94	.7780	.9344	.0044
100	.90	.88	50	.95	.96	.1762	.8920	.0120
100	.90	.88	50	.95	.98	.0638	.8860	.0060
100	.90	.87	50	.95	.96	.1407	.8811	.0111
100	.90	.90	50	.95	.94	.4790	.9130	.0130
100	.90	.93	50	.95	.96	.5053	.9401	.0101
100	.90	.92	50	.95	.98	.1805	.9292	.0092
100	.90	.91	50	.95	.94	.5691	.9209	.0109
100	.90	.91	50	.95	.98	.1394	.9186	.0036
100	.90	.89	50	.95	.98	.1074	.8987	.0087
100	.90	.90	50	.95	.96	.2726	.9129	.0129

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
10	.80	.70	20	.99	.95	.1710	.7365	.0365
10	.80	.70	20	.99	.95	.1710	.7365	.0365
10	.80	.70	20	.99	.95	.1710	.7365	.0365
10	.80	.60	20	.99	.95	.0784	.6254	.0254
10	.80	.80	20	.99	.95	.3577	.8395	.0395
10	.80	.90	20	.99	.95	.7313	.9211	.0211
10	.80	.90	20	.99	.95	.7313	.9211	.0211
10	.80	.90	20	.99	.95	.7313	.9211	.0211
10	.80	.90	20	.99	.95	.7313	.9211	.0211
10	.80	.50	20	.99	.90	.1024	.5372	.0372
10	.99	.90	20	.80	.80	.5024	.8666	.0334
10	.99	.90	20	.80	.80	.5024	.8666	.0334
10	.99	.90	20	.80	.85	.6641	.8800	.0200
10	.99	.90	20	.80	.85	.6641	.8800	.0200
10	.99	.90	20	.80	.85	.6641	.8800	.0200
10	.99	.90	20	.80	.85	.6641	.8800	.0200
10	.99	.90	20	.80	.90	.8673	.9000	.0000
10	.99	.90	20	.80	.90	.8673	.9000	.0000
10	.99	.90	20	.80	.65	.2019	.8580	.0420
10	.99	.90	20	.80	.75	.3731	.8592	.0408
20	.99	.95	10	.90	.80	.3577	.9105	.0395
20	.99	.95	10	.90	.80	.3577	.9105	.0395
20	.99	.95	10	.90	.80	.3577	.9105	.0395
20	.99	.95	10	.90	.80	.3577	.9105	.0395
20	.99	.95	10	.90	.80	.3577	.9105	.0395
20	.99	.95	10	.90	.90	.7313	.9289	.0211
20	.99	.95	10	.90	.90	.7313	.9289	.0211
20	.99	.95	10	.90	.90	.7313	.9289	.0211
20	.99	.95	10	.90	.70	.1710	.9135	.0365
20	.99	.90	10	.90	.90	.8170	.9000	.0000

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
25	.99	.96	50	.90	.92	.5067	.9465	.0135
25	.99	.96	50	.90	.92	.5067	.9465	.0135
25	.99	.96	50	.90	.92	.5067	.9465	.0135
25	.99	.96	50	.90	.92	.5067	.9465	.0135
25	.99	.96	50	.90	.90	.3873	.9432	.0168
25	.99	.96	50	.90	.88	.2959	.9417	.0183
25	.99	.96	50	.90	.88	.2959	.9417	.0183
25	.99	.96	50	.90	.96	.8631	.9600	.0
25	.99	.96	50	.90	.96	.8631	.9600	.0
25	.99	.96	50	.90	.96	.8631	.9600	.0
25	.99	.96	50	.80	.82	.1453	.9422	.0178
25	.99	.96	50	.80	.82	.1453	.9422	.0178
25	.99	.96	50	.80	.82	.1453	.9422	.0178
25	.99	.96	50	.80	.72	.0312	.9527	.0073
25	.99	.96	50	.80	.80	.0987	.9456	.0144
25	.99	.96	50	.80	.84	.1803	.9417	.0183
25	.99	.96	50	.80	.84	.1803	.9417	.0183
25	.99	.96	50	.80	.92	.5074	.9465	.0135
25	.99	.96	50	.80	.90	.3880	.9432	.0168
25	.99	.96	50	.80	.74	.0459	.9503	.0097
25	.95	.92	50	.90	.92	.8825	.9200	.0000
25	.95	.92	50	.90	.92	.8825	.9200	.0000
25	.95	.92	50	.90	.86	.4939	.9000	.0200
25	.95	.96	50	.90	.92	.5000	.9467	.0133
25	.95	.96	50	.90	.92	.5000	.9467	.0133
25	.95	.88	50	.90	.86	.7790	.8712	.0088
25	.95	.88	50	.90	.90	.9763	.8899	.0099
25	.95	.92	50	.90	.94	.9872	.9299	.0099
25	.95	.92	50	.90	.88	.6126	.9048	.0152
25	.95	.96	50	.90	.94	.6631	.9520	.0080

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
25	.80	.80	50	.99	.98	.0516	.8088	.0088
25	.80	.80	50	.99	.98	.0516	.8088	.0088
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.84	50	.99	.98	.1008	.8528	.0128
25	.80	.76	50	.99	.98	.0262	.7656	.0056
25	.80	.76	50	.99	.98	.0262	.7656	.0056
25	.80	.72	50	.99	.98	.0131	.7234	.0034
25	.80	.72	50	.99	.98	.0131	.7234	.0034
25	.80	.84	50	.99	.94	.3324	.8649	.0249
50	.99	.98	25	.90	.92	.3793	.9635	.0165
50	.99	.98	25	.90	.92	.3793	.9635	.0165
50	.99	.98	25	.90	.92	.3793	.9635	.0165
50	.99	.98	25	.90	.92	.3793	.9635	.0165
50	.99	.98	25	.90	.88	.1954	.9637	.0163
50	.99	.98	25	.90	.88	.1954	.9637	.0163
50	.99	.98	25	.90	.88	.1954	.9637	.0163
50	.99	.98	25	.90	.84	.1008	.9672	.0128
50	.99	.98	25	.90	.84	.1008	.9672	.0128
50	.99	.98	25	.90	.96	.7428	.9715	.0085
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.84	.1008	.9672	.0128
50	.99	.98	25	.80	.76	.0269	.9742	.0058
50	.99	.98	25	.80	.76	.0269	.9742	.0058
50	.99	.98	25	.80	.80	.0516	.9712	.0088
50	.99	.98	25	.80	.80	.0516	.9712	.0088
50	.99	.98	25	.80	.92	.3793	.9635	.0165
50	.99	.98	25	.80	.72	.0132	.9766	.0034

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
50	.99	.98	100	.90	.88	.0632	.9741	.0059
50	.99	.98	100	.90	.91	.1382	.9715	.0085
50	.99	.98	100	.90	.91	.1382	.9715	.0085
50	.99	.98	100	.90	.93	.2338	.9705	.0095
50	.99	.98	100	.90	.89	.0820	.9732	.0068
50	.99	.98	100	.90	.89	.0820	.9732	.0068
50	.99	.98	100	.90	.87	.0491	.9749	.0051
50	.99	.98	100	.90	.87	.0491	.9749	.0051
50	.99	.98	100	.90	.87	.0491	.9749	.0051
50	.99	.94	100	.90	.93	.7780	.9356	.0044
50	.95	.96	100	.90	.88	.1762	.9480	.0120
50	.95	.98	100	.90	.88	.0638	.9740	.0060
50	.95	.96	100	.90	.87	.1407	.9489	.0111
50	.95	.94	100	.90	.90	.4790	.9270	.0130
50	.95	.96	100	.90	.93	.5053	.9499	.0101
50	.95	.98	100	.90	.92	.1805	.9708	.0092
50	.95	.94	100	.90	.91	.5691	.9291	.0109
50	.95	.98	100	.90	.91	.1394	.9714	.0086
50	.95	.98	100	.90	.89	.1074	.9713	.0087
50	.95	.96	100	.90	.90	.2726	.9471	.0129
50	.95	.96	25	.80	.84	.2090	.9393	.0207
50	.95	.96	25	.80	.84	.2090	.9393	.0207
50	.95	.92	25	.80	.76	.1333	.8952	.0248
50	.95	.98	25	.80	.72	.0132	.9766	.0034
50	.95	.94	25	.80	.68	.0360	.9310	.0090
50	.95	.96	25	.80	.76	.0636	.9480	.0120
50	.95	.96	25	.80	.72	.0348	.9519	.0081
50	.95	.94	25	.80	.80	.1996	.9167	.0233
50	.95	.98	25	.80	.76	.0261	.9744	.0056
50	.95	.98	25	.80	.88	.1969	.9635	.0165

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
50	.80	.80	25	.99	.96	.1008	.8147	.0147
50	.80	.84	25	.99	.96	.1803	.8583	.0183
50	.80	.84	25	.99	.96	.1803	.8583	.0183
50	.80	.76	25	.99	.96	.0561	.7706	.0106
50	.80	.76	25	.99	.96	.0561	.7706	.0106
50	.80	.78	25	.99	.96	.0511	.7888	.0088
50	.80	.78	25	.99	.96	.0511	.7888	.0088
50	.80	.72	25	.99	.88	.2073	.7475	.0275
50	.80	.82	25	.99	.96	.1331	.8364	.0164
50	.80	.70	25	.99	.96	.0245	.7062	.0062
50	.80	.80	25	.95	.92	.2588	.8247	.0247
50	.80	.84	25	.95	.96	.1803	.8583	.0183
50	.80	.76	25	.95	.92	.1609	.7822	.0222
50	.80	.78	25	.95	.96	.0511	.7888	.0088
50	.80	.78	25	.95	.96	.0511	.7888	.0088
50	.80	.72	25	.95	.96	.0312	.7273	.0073
50	.80	.82	25	.95	.96	.1331	.8364	.0164
50	.80	.76	25	.95	.96	.0561	.7706	.0106
50	.80	.84	25	.95	.92	.4036	.8630	.0230
50	.80	.70	25	.95	.96	.0245	.7062	.0062
100	.99	.99	50	.80	.76	.0006	.9899	.0001
100	.99	.99	50	.80	.84	.0105	.9834	.0016
100	.99	.99	50	.80	.90	.0583	.9850	.0050
100	.99	.99	50	.80	.92	.1077	.9832	.0068
100	.99	.99	50	.80	.86	.0168	.9879	.0021
100	.99	.99	50	.80	.88	.0307	.9867	.0033
100	.99	.99	50	.80	.82	.0052	.9891	.0009
100	.99	.99	50	.80	.82	.0052	.9891	.0009
100	.99	.99	50	.80	.78	.0013	.9897	.0003
100	.99	.96	50	.80	.80	.0437	.9533	.0067

BASE DATA SET			TEST DATA SET					
NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	NR. OF TRIALS	SINGLE TRIAL PROB. OF SUCCESS	POINT ESTIMATE OF REL.	TRW K	TRW ESTIMATE OF REL.	ADJUST. TO BASE POINT ESTIMATE
100	.95	.94	50	.80	.76	.0273	.9352	.0048
100	.95	.98	50	.80	.72	.0006	.9798	.0002
100	.95	.94	50	.80	.70	.0056	.9387	.0013
100	.95	.95	50	.80	.76	.0168	.9469	.0031
100	.95	.96	50	.80	.99	.3201	.9673	.0073
100	.95	.97	50	.80	.74	.0026	.9694	.0006
100	.95	.97	50	.80	.78	.0038	.9683	.0017
100	.95	.99	50	.80	.84	.0090	.9687	.0013
100	.95	.96	50	.80	.78	.0165	.9571	.0029
100	.95	.94	50	.80	.74	.0164	.9368	.0032
100	.80	.82	50	.99	.98	.0129	.8220	.0020
100	.80	.77	50	.99	.98	.0037	.7708	.0008
100	.80	.77	50	.99	.98	.0037	.7708	.0008
100	.80	.75	50	.99	.98	.0018	.7504	.0004
100	.80	.79	50	.99	.94	.0530	.7976	.0076
100	.80	.79	50	.99	.98	.0057	.7911	.0011
100	.80	.79	50	.99	.98	.0057	.7911	.0011
100	.80	.84	50	.99	.93	.0222	.8430	.0030
100	.80	.84	50	.99	.98	.0222	.8430	.0030
100	.80	.84	50	.99	.93	.0222	.8430	.0030
100	.80	.82	50	.95	.92	.1919	.8361	.0161
100	.80	.77	50	.95	.98	.0033	.7707	.0007
100	.80	.77	50	.95	.98	.0033	.7707	.0007
100	.80	.75	50	.95	.94	.0215	.7540	.0040
100	.80	.79	50	.95	.94	.0401	.7958	.0058
100	.80	.77	50	.95	.90	.1835	.8071	.0171
100	.80	.84	50	.95	.92	.2727	.8571	.0171
100	.80	.84	50	.95	.96	.0705	.8479	.0079
100	.80	.79	50	.95	.96	.0211	.7935	.0035
100	.80	.84	50	.95	.96	.0705	.8479	.0079

```
C
C     PROGRAM ONE
C      ..........................................................
C
C      PURPOSE
C        SOLVES FOR WEIGHTING FACTOR USED IN TRW METHOD OF
C        CALCULATING OVERALL RELIABILITY.  OUTPUT IS THE
C        POINTS WHERE TWO BETA DENSITIES INTERSECT, THE AREA
C        UNDEREACH CURVE FROM ORIGIN TO THOSE POINTS (CALLED
C        P(X) ), THE HEIGHT OR DENSITY AT THOSE POINTS, AND
C        THE WEIGHTING OR K FACTOR.
C
C      METHOD
C
C        RTPLBS IS USED TO SOLVE THE POLYNOMIAL
C
C          X**(A-C)*(1-X)**(B-D) = Y
C
C        WHERE
C
C        Y=((C+D-1) *(A-1) *(B-1) )/((A+B-1) *(C-1) *(D-1) )
C
C        IF A-C AND B-D ARE BOTH NEGATIVE THEN THE POLYNOMIAL
C
C          X**(C-A)*(1-X)**(D-B) = 1/Y
C
C        SHOULD BE SUBSTITUTED.  IF ONLY ONE OF THESE TERMS
C        IS NEGATIVE USE PROGRAM TWO.
C
C        SOLUTIONS BETWEEN 0 AND 1 ARE INPUTS FOR BDTR WHICH,
C        WITH SUBSEQUENT PROGRAM LOGIC, SOLVES FOR WEIGHTING
C        FACTOR.
C
C     PARAMETERS
C        COEF-A VECTOR OF COEFICIENTS OF POLYNOMIAL.  MUST
C             BE DECLARED AS REAL*8 OF DIMENSION N+1.
C        A   -NUMBER OF SUCCESSES IN BASE DATA.
C        B   -NUMBER OF FAILURES IN BASE DATA.
C        C   -NUMBER OF SUCCESSES IN TEST DATA.
C        D   -NUMBER OF FAILURES IN TEST DATA.
C        N   -DEGREE OF POLYNOMIAL USED TO DETERMINE POINTS
C             OF INTERSECTION.
C        Y   -CONSTANT TERM IN POLYNOMIAL.
C
C        THE TERMS OF THE POLYNOMIAL MUST BE WORKED OUT
C        MANUALLY AND MUST BE SUPPLIED THROUGH VECTOR
C        COEF.  Y MUST BE SUPPLIED AS FIRST STEP OF THE
C        PROGRAM.  MOST OF THE TERMS OF Y CANCELL.  AN ARITH-
C        METIC EXPRESSION CAN BE SUPPLIED TO COMPLETE THE
C        CALCULATIONS.  AFTER Y IS ENTERED THE PROGRAM SETS
C        COEF(N+1) = Y.
C
C        INSERT DIMENSION OF VECTOR COEF AS N+1 IN TYPE STATE
C        MENT AT LINE 0007 OF PROGRAM.
C        INSERT  PARAMETERS A,B,C,D,N, AND VECTOR COEF IN
C        DATA STATEMENT AT LINE 0008 OF PROGRAM.
C        INSERT PARAMETER Y AT LINE 0009 OF PROGRAM.
C
C     LIMITS ON USE OF PROGRAM
C        N MUST BE LESS THAN 49
C        EXPONENTS OF POLYNOMIAL MUST NOT BE NEGATIVE
C
C        IF EITHER OF THESE LIMITATIONS ARE NOT MET USE
C        PROGRAM TWO AND CP-67/CMS TIME SHARING SYSTEM.
C
C     SUBROUTINES REQUIRED TO BE SUPPLIED BY USER
C        RTPLSB
C        BDTR
C        DLGAM
C        NDTR
C        CDTR
C
```

```
C      ..........................................................
C
       CALL ERRSET (207,300,-1,1)
 1000 FORMAT('1','      COMPUTED CONSTANT IS ',D13.6)
 1100 FORMAT('0',5X,'ROOT IS ',D23.6)
 1200 FORMAT('0',5X,3D23.6)
 1700 FORMAT('0',5X,'FOR X= ',E13.6,'   A BETA(',F5.1,' ,',
     2F5.1,' ) HAS P(X)  '       ,F10.7,' AND DENSITY ',F10.7
     3/1X,'THE ERROR CODE IS ',I4//)
 1800 FORMAT ('0',   '   K FACTOR IS ',   F10.7)
 0007 REAL*8 COEF(    ),U(49),V(49),CONV(49),Y,ROOT(5),
     2DEN1(2),DEN2(2),PROB1(2),PROB2(2)
 0008 DATA COEF/                                                   /
     2U,V,CONV/49*0.0,49*0.0,49*0.0/,ROOT/5*0.0/,
     3PROB1/2*0.0/,PROB2/0.0/,DEN1/2*0.0/,DEN2/2*0.0/,N/    /
     4,A,B,C,D/                             /
 0009 Y =
      Y = -Y
      WRITE (6,1000) Y
      M = N + 1
      I = 1
      COEF(M)=Y
C
C     CALL RTPLSB TO GET  ROOTS AND DETERMINE REAL ROOTS
C
      CALL RTPLSB (N,COEF,U,V,CONV, IER)
      DO 25 J=1,N
      IF (V(J)) 25,21,25
   21 IF (U(J)) 25,25,26
   26 IF (U(J) - 1.0) 27,27,25
   27 ROOT (I) = U(J)
      I = I + 1
   25 CONTINUE
      IF (ROOT(1)-ROOT(2)) 30,30,31
   31 TEMP=ROOT(1)
      ROOT(1)=ROOT(2)
      ROOT(2)=TEMP
   30 II = I - 1
      DO 50 K =1,2
C
      CALL BDTR (ROOT(K),A,B,PROB1(K),DEN1(K) ,IER)
      WRITE (6,1700) ROOT(K),A,B,PROB1(K),DEN1(K),IER
      CALL BDTR(ROOT(K),C,D,PROB2(K),DEN2(K),IER)
      WRITE (6,1700) ROOT(K),C,D,PROB2(K),DEN2(K),IER
   50 CONTINUE
      IF (PROB1(1)-PROB2(1)) 52,54,53
   52 Z=PROB1(1)+PROB2(2)-PROB2(1)+1.0-PROB1(2)
      GO TO 60
   54 IF (PROB1(2) - PROB2(2))  53,53,52
   53 Z=PROB2(1)+PROB1(2)-PROB1(1)+1.0-PROB2(2)
   60 WRITE (6,1800) Z
      END
```

```
C
C     PROGRAM TWO CP-67/CMS NAME FOR PROGRAM IS EVAL2
C     ..............................................................
C
C     PURPOSE
C        WHEN PROGRAM ONE IS NOT USED TO SOLVE FOR WEIGHTING
C        FACTOR, THIS SIMPLE LOOK UP TYPE PROGRAM CAN BE USED
C        WITH CP-67/CMS TO CONVERGE TO POINTS OF INTER
C        SECTION OF TWO BETA CURVES AND TO GET AREAS UNDER
C        THE CURVES FROM THE ORIGIN TO THE POINTS OF
C        INTERSECTION.  CALCULATION OF THE WEIGHTING FACTOR
C        CAN THEN BE DONE BY HAND AFTER OBSERVING WHICH CURVE
C        IS LOWER TO THE LEFT OF THE INTERSECTION.
C
C     METHOD
C        THE PARAMETERS FOR TWO BETA DISTRIBUTIONS ARE READ
C        IN AS INPUTS.  ALSO INPUTS  BY A READ STATEMENT
C        SUPPLIED TO SUBROUTINE BDTR WHICH SUPPLIES AS OUTPUT
C        THE DENSITIES OR HEIGHTS OF THE TWO CURVES AT THE
C        INPUT POINTS.  THE USER CAN OBSERVE CONVERGENCE
C        ON INTERSECTIONS (POINTS OF EQUAL HEIGHT ON BOTH
C        CURVES).  HE CAN THEN READ IN NEW VALUES FOR INPUT
C        POINTS UNTIL HE LOCATES THE INTERSECTIONS.  THIS CAN
C        BE DONE QUITE RAPIDLY WITH TIME SHARING.
C
C     PARAMETERS
C        A-NUMBER OF SUCCESSES IN BASE DATA.
C        B-NUMBER OF FAILURES IN BASE DATA.
C        C-NUMBER OF SUCCESSES IN TEST DATA.
C        D-NUMBER OF FAILURES IN TEST DATA.
C        S-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        T-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        U-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        V-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        W-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        X-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        Y-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C        Z-ORDINATE AT WHICH BETA CURVES ARE EVALUATED.
C
C     SUBROUTINES REQUIRED TO BE SUPPLIED BY USER
C        BDTR
C        DLGAM
C        NDTR
C        CDTR
C
C     ..............................................................
C
OFFLINE READ EVAL2  FORTRAN
  800 FORMAT(  8F4.3)
  900 FORMAT(4F4.0)
 1700 FORMAT(     1X,'FOR X= ',E13.6,'  A BETA(',F5.1,' ,',
     2F5.1,' ) HAS P(X)  '       ,F10.7,' AND DENSITY ',F10.7
     3,I4)
      READ(5,900) A,B,C,F
      READ(5,800)S,T,U,V,W  ,X,Y,Z
      CALL BDTR(S,A,B,P,D,IER)
      WRITE(6,1700) S,A,B,P,D,IER
      CALL BDTR(S,C,F,P,D,IER)
      WRITE(6,1700) S,C,F,P,D,IER
      CALL BDTR(T,A,B,P,D,IER)
      WRITE(6,1700) T,A,B,P,D,IER
      CALL BDTR(T,C,F,P,D,IER)
      WRITE(6,1700) T,C,F,P,D,IER
      CALL BDTR(U,A,B,P,D,IER)
      WRITE(6,1700) U,A,B,P,D,IER
      CALL BDTR(U,C,F,P,D,IER)
      WRITE(6,1700) U,C,F,P,D,IER
      CALL BDTR(V,A,B,P,D,IER)
      WRITE(6,1700) V,A,B,P,D,IER
      CALL BDTR(V,C,F,P,D,IER)
      WRITE(6,1700) V,C,F,P,D,IER
      CALL BDTR(W,A,B,P,D,IER)
```

```
WRITE(6,1700) W,A,B,P,D,IER
CALL BDTR(W,C,F,P,D,IER)
WRITE(6,1700) W,C,F,P,D,IER
CALL BDTR(X,A,B,P,D,IER)
WRITE(6,1700) X,A,B,P,D,IER
CALL BDTR(X,C,F,P,D,IER)
WRITE(6,1700) X,C,F,P,D,IER
CALL BDTR(Y,A,B,P,D,IER)
WRITE(6,1700) Y,A,B,P,D,IER
CALL BDTR(Y,C,F,P,D,IER)
WRITE(6,1700) Y,C,F,P,D,IER
CALL BDTR(Z,A,B,P,D,IER)
WRITE(6,1700) Z,A,B,P,D,IER
CALL BDTR(Z,C,F,P,D,IER)
WRITE(6,1700) Z,C,F,P,D,IER
END
```

BIBLIOGRAPHY

1. Handbook of Mathematical Functions, edited by Milton Abramowitz and Irene A. Stegun, Dover Publications, Inc., 1965.

2. Hottenroth, F. W., K Factor Generation Method, TRW Corporation Interoffice Correspondence 6330.53.71-414, 15 March 1971.

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13. ABSTRACT

A computer program was written that carries out reliability assessments according to a method proposed by the TRW Corporation. This method combines point estimates for reliability from different sources into an overall point estimate. The program was used to calculate the overall point estimate for cases covering a range of sample sizes, and underlying probabilities of success in order to make a judgement on the usefulness of the method.

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